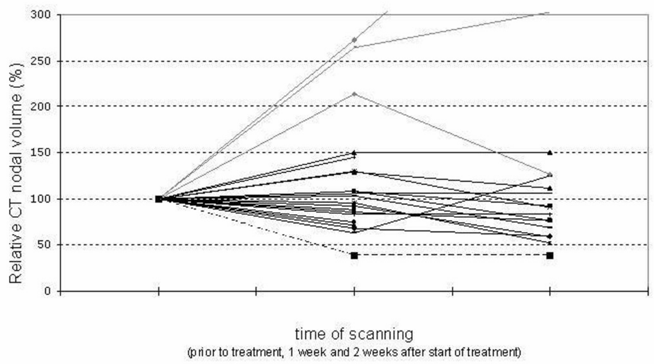
orthogonal movements, of the nodal areas was initially 5.7 mm ± 2.9 mm, which was somewhat smaller than the tumor motion (7.8 mm ± 4.8 mm). The motion of the lymph nodes decreased during therapy (5.8 mm after 1 week and 5.3 mm after 2 weeks) but was not statistically significant different. No difference in motion and motion changes was observed between the locations of the lymph nodal areas.

Conclusion: A large variability of changes in nodal volume between the patients was observed, but is not clinically relevant since the volumes and hence the volume changes are small. The motion of the nodal areas is smaller than the tumor motion and does not change during therapy. Therefore smaller internal margins can be applied for the nodal areas compared to the internal margin for the primary tumor.



PD5-1-8 **Technical Advances on Radiation Therapy, Thu, 12:30 - 14:15**

4D CT imaging impacts lung volume definitions and dose-volume relationships in radiation treatment of non-small cell lung cancer

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Purpose: To characterize lung volume definitions at various CT imaging conditions for advanced non-small-cell lung cancer (NSCLC) patients. Due to respiratory motion, lung volumes measured by CT imaging can exhibit significant volumetric variations, which can affect the assessment of dose-volume relationships for radiotherapy. The goal of this study was to quantify the range of uncertainties in the dose-volume relationships and suggest a unified correction procedure.

Methods: Forty stage III/IV NSCLC patients were randomly selected for this study. For all patients, a fast CT scan and a 4D CT scan were acquired under natural breathing conditions. The fast CT scan (free breathing, or FB) represents the typical clinical practice for CT-based radiotherapy treatment planning. The 4D CT scan represents the state-of-art volumetric imaging technique to explicitly include respiratory motion. We define the lung volumes measured in 4D CT at the end of inspiration and at the end of expiration as end inspiratory volume (EIV) and end expiratory volume (EEV), respectively. The percent of volumes at 5Gy (V5), 20Gy (V20), and 50Gy (V50) were calculated and compared for each volume definition at FB, EEV, EIV, and a specially computed average density volume from 4D CT.

Results: The total lung EIV was on average 13.9% larger than the EEV (1SD 5.1%; range: 5.7% to 28%). While the average density of the lung at the end of inspiration was 8% lower than the density of the lung at the end of expiration, the total mass enclosed in the lung volume was 4.6% higher at the end of inspiration than at the end of expiration, possibly due to the blood inflow caused by the negative pressure. There was an excellent linear relationship between the density ratio and the volume ratio at the two breathing extremes among all patients ($R=0.86$; $p<0.0001$). We found a strong volume impact to the dose-volume relationship. The V5, V20, and V50 between EIV and EEV varied from -15% to +12%, -21% to +17%, and -6% to +3%, respectively. The V5, V20, and V50 defined on FB CT scans were systematically smaller than those defined in EEV (average=-1.9% for V5; -1.3% for V20; and -0.8% for V50) and varied significantly (range from -12% to +1%), representing the uncertainties in the dose-volume analysis. These variations were primary due to volume differences at different breathing phases. The impact of dose distribution by anatomy changes was minimal (V5, V20, and V50 variations were less than 1% for the same volume definition). We found that the use of a simple scaling factor can effectively correct or convert the dose-volume parameters from one phase to another using the population data obtained in this study.

Conclusions: Significant variations in dose-volume parameters were found in current practice when using different volume definitions. We recommend reporting dose-response data on standardized volume definitions (such as the end of expiration, which is more nature for individual patients). Parameters found in this study can be used to convert these dose-volume parameters from one volume definition to another based on population average.

PD5-2-1 **Clinical Data from Radiation Therapy, Thu, 12:30 - 14:15**

Effective local control of stage III non-small cell lung cancer (NSCLC) with accelerated radiotherapy for patients with unfavorable prognostic factors

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Purpose: This retrospective study was performed to evaluate the efficacy and toxicity of accelerated radiotherapy for patients with Stage III NSCLC with unfavorable prognostic factors (PF).

Materials and Methods: Between 1994 and 2004, 113 patients with Stage III NSCLC and unfavorable PF were treated with accelerated radiotherapy of 45 Gy in 15 fractions over 3 weeks at the University of Texas M.D. Anderson Cancer Center. To compare the efficacy of accelerated radiotherapy with conventional radiotherapy, 222 patients with Stage III NSCLC who received conventional radiotherapy of >60 Gy between 1987 and 2005 were identified. Their medical and radiological records were retrospectively reviewed and analyzed for overall survival (OS), local-regional control (LRC), disease free survival (DFS) and distant metastasis-free survival (DMFS). Acute and late toxicity of accelerated radiotherapy with regard to esophagus and lung were also analyzed.

Results: Compared to the patients treated with conventional radiotherapy, the patients treated with accelerated radiotherapy were older in age, had poorer PF and received less chemotherapy. The median age was 67 ($P<0.00001$), 91 patients (81%) had a weight loss of >10% ($P<0.0001$) and 43 patients (38%) had Karnofsky performance status (KPS) <70 ($P<0.0001$). 75 patients (66%) received no chemotherapy. Median follow-up was 10 months for the accelerated group and 13 months for the conventional radiotherapy group. OS was statistically higher in patients treated with conventional radiotherapy. OS at 2 and 5 years for the accelerated radiotherapy group were 16% and 3%, respectively, and 44% and 19% for the conventional radiotherapy group (P<0.00001). However, there was no statistical difference in LRC, DFS and DMFS between the two groups. LRC at 2 and 5 years for the accelerated radiotherapy group were 47% and 19%, compared to 48% and 37% for the conventional radiotherapy group. DFS at 2 and 5 years for the accelerated group were 24% and 10%, 30% and 19% for the conventional radiotherapy group. In terms of toxicity, 12 patients (11%) had Common Toxicity Criteria for Adverse Events (CTCAE) grade 3 or more treatment related pneumonitis. 6 patients (5%) had CTCAE grade 3 acute esophagitis and only 1 patient had RTOG grade 3 late esophageal toxicity.

Conclusions: In spite of treating the patients with poorer PF, accelerated radiotherapy of 45 Gy in 15 fractions over 3 weeks achieved comparable local-regional control for Stage III NSCLC with conventional radiotherapy. Toxicity of accelerated radiotherapy was acceptable. Accelerated radiotherapy is reasonable strategy for patients who have locally advanced NSCLC with unfavorable prognostic factors, since their main goal of treatment is to improve their quality of life within a limited time.

PD5-2-2 **Clinical Data from Radiation Therapy, Thu, 12:30 - 14:15**

Impact of mediastinal nodal mobility on the accuracy of transbronchial needle aspiration (TBNA) without real-time imaging

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Background: The diagnostic yield of TBNA can be highly variable, with a meta-analysis reporting the pooled sensitivity and specificity to be only 39% and 99%, respectively. Nodal position is often estimated from the distance between the carina and a visible lymph node, as measured on a diagnostic CT scan. However, breath-hold conventional CT scans do not account for nodal motion, and nodal motion may explain the lower yields when TBNA is performed without real-time ultrasound imaging. We studied mediastinal nodal motion on 4-dimensional (4D) CT scans.

Methods: A total of 47 distinct mediastinal nodes were identified on 4DCT scans performed for radiotherapy planning in 25 patients with lung cancer. Nodes were mainly located at station 4R, 4L, 7 and 2R and each identified node was contoured in all 10 phases of the 4DCT. Nodal motion was derived from the displacement of the center of mass in the respiratory phases. In order to evaluate whether the distance between the center of mass of each node and the carina remained constant during the respiratory cycle, this distance was derived for all respiratory phases using the coordinates of both structures.

Results: The mean nodal diameter was 10.2 ± 4.0 mm (1SD) and mean nodal volume 1.8 ± 2.3 cc. Mobility was maximal in the cranio-caudal axis (mean of 4.7 ± 2.3 mm) and the corresponding medio-lateral and ventro-dorsal mobility was 2.8 ± 1.9 mm and 2.4 ± 1.8 mm, respectively. The mean 3-dimensional displacement of nodal center was 6.2 ± 2.9 mm, and this exceeded 10 mm in 5 nodes (Table 1). The nodal mass was constantly present in only 25 ± 14% of the region encompassing all nodal positions. The mean variation in cranio-caudal distance between all nodes and carina position during respiration was 5.3 ± 2.1 mm (range 2.2-10.5 mm).

Conclusions: Both nodal motion and the varying distance between carina and nodal position, may explain the lower diagnostic yields for TBNA procedures performed without real-time guidance.

Table 1: Three-dimensional nodal mobility per location studied

Location	No. of nodes	med-lat (mm)		ventro-dors (mm)		cran-caud (mm)		3D vector (mm)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
2L	2	2.3	1.4	1.8	1.2	3.2	1.0	4.4	2.0
2R	7	2.4	2.5	2.1	2.5	2.6	1.8	4.3	2.9
4L	9	1.9	1.2	1.9	0.8	5.1	1.2	5.8	1.5
4R	14	2.9	1.3	2.5	1.5	4.8	2.5	6.4	2.6
5	4	4.7	3.3	3.6	4.6	5.9	1.8	8.7	5.2
6	2	3.0	0.7	6.1	2.7	4.9	0.5	8.4	2.5
7	7	3.8	1.6	2.2	1.1	6.5	2.3	8.1	2.2
8	2	1.5	1.1	0.8	0.2	1.7	0.4	2.4	1.0
All nodes	**47**	**2.8**	**1.9**	**2.4**	**1.8**	**4.7**	**2.3**	**6.2**	**2.9**

PD5-2-3 **Clinical Data from Radiation Therapy, Thu, 12:30 - 14:15**

Translating research into routine clinical practice: image-guided lung stereotactic radiation therapy for unresectable patients with early stage lung cancer

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Background: Stereotactic Body Radiation Therapy (SBRT) has emerged as a non-invasive treatment option for unresectable early stage non-small cell lung cancer (NSCLC), delivering very high radio-ablative doses of RT to the primary tumor. To ensure efficacy of treatment and patient safety, high precision planning and careful treatment delivery under vigilant quality assurance are needed. We present the evolution of SBRT practice at Princess Margaret Hospital with an emphasis on accuracy of treatment set up and verification using image-guided techniques.

Methods: From Oct 2004 to Feb 2007, we treated 46 patients (pts) with T1T2N0MO NSCLC with SBRT (48 tumors were treated). RT schedule for peripheral tumors was 60 Gy/3 fractions over 2 weeks (for 29 tumors, 12 of the pts were part of the RTOG 0236 phase II study). When organ at risk tolerance doses were not achievable, either 54 Gy/3 fr (3 pts) or 48 Gy/4 fr (10 tumors, all T1) was employed. Central tumors were treated with a lower dose of 50 Gy/10 fr schedule (6 pts). 4DCT simulation was acquired in all but 9 pts who were too large for the scanner. All tumor and normal tissue contours and final plans are reviewed in weekly multidisciplinary SBRT rounds. On the treatment unit, cone beam CT (CBCT) is used for image guidance with therapist manually matching directly to the tumor, adjusting the patient's position for discrepancies >3mm. CBCT is performed for initial localization and repeated during treatment to verify the tumor position. We compared CBCT soft tissue (tumor) matching to bone matching (which would mimic matching used in conventional portal imaging). Patients are followed every 3 months with radiological and clinical assessment.

Results: Median pt age was 73 yrs (48-96); mean tumor size was 2.6 cm (range 0.7-5.7). Median follow-up is 10 mo (range 0-26 mo). Acute RT toxicity was generally mild with grade G1 fatigue the most common